# Cost-Effective Allocation Of Government Funds To Prevent HIV Infection

Emphasis should be placed on cost-effective strategies, instead of expanding the use of strategies that are inherently limited or costly.

**by Deborah A. Cohen, Shin-Yi Wu, and Thomas A. Farley**

**PROLOGUE:** The relentless upward spiral of health spending in recent years has only heightened the fierce competition among policy priorities for public dollars. Despite increased attention post-9/11 to ensuring preparedness capacity, public health has often been treated as the health policy stepchild—falling to the end of the appropriations line. The frustration of public health officials—groping for ways to persuade often skeptical policymakers of the necessity of funding public health programs as unglamorous as they are crucial—is palpable and equally endemic. Thus, it is little wonder that the American Public Health Association chose evidence-based policy and practice as the theme for its annual meeting this year.

Within the universe of public health programmatic planning, HIV prevention strategy has been a lightning rod for controversy since its inception. This tumult has emanated from the mythology and reality surrounding the populations who account for the bulk of the disease prevalence. Thus, as often as not, ideology and politics, not support for what works, have driven allocation of HIV prevention dollars. The most recent iteration of the HIV prevention strategy of the U.S. Centers for Disease Control and Prevention (CDC), announced in 2003, epitomizes such a disparity between ideology versus evidence-based programmatic planning, if the reaction of the HIV/AIDS advocacy community is any gauge.

The numbers show that rates of new HIV infections have not greatly diminished over the past five years. In citing this reality as substantiation for the assertion that the efficacy of current HIV prevention strategies has likely stagnated, the authors of this paper highlight the renewed urgency in allocating scarce public health dollars toward strategies that the evidence shows are most cost-effective in terms of infections prevented, rather than those that, although politically expedient, have limited potential for success. The authors apply principles of cost-benefit analysis to provide policymakers with the evidentiary basis for a system of rational resource allocation. Deborah Cohen (dcohen@rand.org) is a senior natural scientist at RAND; Shin-Yi Wu is an associate engineer there. Thomas Farley is a professor in the Department of Community Health Sciences, Tulane University School of Public Health and Tropical Medicine, in New Orleans.



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**ABSTRACT:** Relative to the magnitude of the epidemic, government funds available for HIV prevention are scarce. To optimize use of funds, we applied a mathematical model of the cost of HIV prevention interventions using national data on HIV risk-group size and HIV prevalence. This procedure suggested an allocation of funds across nine interventions to potentially prevent an estimated 20,000 infections annually, compared with the estimated 7,300 infections potentially prevented through four interventions now recommended by the Centers for Disease Control and Prevention (CDC). The optimal allocation will involve a combination of intensive interventions for high-prevalence populations and inexpensive large-scale interventions for lower-prevalence populations.

Although progress has been made in stemming the epidemic of HIV infection, there are still an estimated 40,000 new infections each year in the United States alone.[1] The Institute of Medicine recently recommended that HIV prevention resources be allocated to maximize the number of infections prevented, and the base of knowledge of HIV prevention has now progressed to the point that this allocation can be conducted using a rational, quantitative approach that maximizes the number of infections prevented.[2] To date, cost-effectiveness modeling has not been widely used in public health as a way to allocate limited prevention resources. We hope, therefore, that this demonstration of its usefulness in preventing HIV/AIDS can serve as an example in the development of strategies to prevent other public health problems.

The U.S. Centers for Disease Control and Prevention (CDC) has set a goal of preventing half of the estimated 40,000 new infections in the United States each year.[3] In 2004 the CDC provided $415.5 million to state and local health departments to achieve this goal, out of the $668 million budgeted domestically for HIV prevention.[4] Total prevention dollars constitute less than 10 percent of all federal funds targeted to HIV.[5] This investment is small when we consider the magnitude of the AIDS epidemic as measured by lives lost or medical costs from infections not prevented. It is thus important to allocate prevention funds optimally.

To receive CDC prevention funds, states and localities are required to use epidemiological data to identify interventions that target the highest-risk groups and to gain community consensus about interventions to be funded. However, until recently, the CDC did not specify the nature of the preventive interventions—with the exception of counseling and testing. Instead, for most of the past ten years, states and localities have largely retained control over resource allocation decisions, as long as health officials consult with and obtain approval from local community planning groups in setting priorities.

In 2003 the CDC redirected efforts to prevent HIV infection in adults, placing a particularly strong emphasis on just four interventions: "1) Make HIV testing a routine part of medical care whenever and wherever patients go for care, 2) Use new models for diagnosing HIV infection outside of traditional medical settings, 3) Prevent new infections by working with people diagnosed with HIV and their partners, and 4) Continue to decrease mother-to-child HIV transmission."[6]

To identify which combination of interventions would have the greatest impact in preventing HIV infection, we have developed "Maximizing the Benefit," a tool to assist state and local planning groups in setting priorities.[7] Although it can be used at the state and local levels, in this study we applied it to the United States as a whole, to estimate the optimal allocation of HIV prevention funds across a range of interventions. We also compared the results of this broad analysis with one limited to using the four interventions emphasized by the CDC.

## Study Data And Methods

"Maximizing the Benefit" estimates the cost-effectiveness of HIV prevention interventions using four different mathematical models: (1) a Bernoulli model for interventions designed to reduce sexual transmission by reducing partner change or increasing condom use; (2) a similar Bernoulli model for interventions designed to reduce needle sharing; (3) a model closely related to the Bernoulli model for interventions designed to reduce cofactors for sexually transmitted diseases (STDs), such as screening and antibiotic treatment for curable STDs; and (4) a "proportionate change" model for interventions shown to be effective based on their reduction in the incidence of other STDs, which are more easily measurable.[8]

■ **Selection of interventions.** "Maximizing the Benefit" includes examples of a wide variety of HIV preventive interventions that (1) have been demonstrated to be effective in reducing HIV incidence, STD incidence, or sexual or needle-sharing behavior likely to affect HIV transmission, based on prospective trials or observational studies; or (2) are commonly used to prevent HIV infection in the United States. The set of interventions also includes those that are conducted for purposes other than preventing HIV but that may have an additional effect of reducing HIV transmission (for example, drug addiction treatment programs and male circumcision). The model does not include interventions such as prevention case management that are directed at HIV-infected people to prevent transmission to partners, since these have not been demonstrated so far to be more effective than treatment alone.[9] Nor does the model include medical treatment of HIV-infected pregnant women or HIV testing and counseling of all pregnant women, because these interventions primarily target a relatively small proportion of infected Americans (an estimated 300 infections per year of mother-to-child transmission) and because they are usually funded by sources other than CDC prevention dollars.[10]

In general, the model demonstrates that interventions are most likely to be more cost-effective than treatment if they either are targeted to high-risk populations (such as men who have sex with men) or are extremely inexpensive per person reached, such as mass media campaigns.

■ **Population assumptions and number reached by interventions.** We made assumptions about the size of the populations at risk and their HIV prevalence based on previous literature and CDC surveillance data (Exhibit 1).[11] According to

**EXHIBIT 1**
**Assumptions About Size Of Populations In The Target Groups And Their HIV Prevalence Or Incidence**

| | | HIV prevalence (or incidence) | |
|---|---|---|---|
| **Target group** | **Number** | **Male** | **Female** |
| Intravenous drug users | 1,000,000<br>600,000<br>150,000 | 0.2<br>0.1<br>0.02 | 0.2<br>0.1<br>0.02 |
| Men who have sex with men (MSM) | 1,700,000<br>600,000[b] | –[a]<br>0.20 | –[a]<br>–[a] |
| People living below poverty[c] | 32,900,000 | 0.005 | 0.005 |
| People ages 18–44[c] | 56,400,000 | 0.015 | 0.015 |
| U.S. population | 280,000,000 | 0.003 | 0.003 |
| HIV-positive people in medical care | 467,000 | 1.0 | 1.0 |
| People eligible/reachable for partner notification annually (partners of HIV-positive people)[d] | 20,000 index patients<br>54,000 partners | Male partners 0.5<br>Female partners 0.17 | Male partners 0.2 |
| People who do not know that they are HIV-positive | 200,000 | 1.0 | 1.0 |
| MSM who could be reached in opinion-leader programs or through community mobilization efforts | 600,000 | 0.2 | –[a] |
| People reachable through the mass media[b] | 70,000,000 | 0.003 | 0.003 |
| People visiting STD clinics annually[e] | 2,000,000 | Incidence 0.0035 | Incidence 0.0035 |

**SOURCES:** See Note 11 in the text; in addition, see below for other sources as they apply.
**NOTE:** STD is sexually transmitted disease.
[a] Not applicable.
[b] Estimated.
[c] 2000 U.S. census.
[d] Based upon an average of 2.7 partners per person; assumes that half are reported to health department.
[e] Stuart Berman and Susan DeLisle, U.S. Centers for Disease Control and Prevention (CDC), personal communication, 6 March 2003; incidence data based upon "Project Respect"; see M.L. Kamb et al., "Efficacy of Risk-Reduction Counseling to Prevent Human Immunodeficiency Virus and Sexually Transmitted Diseases: A Randomized Controlled Trial, Project RESPECT Study Group," *Journal of the American Medical Association* 280, no. 13 (1998): 1161–1167.

these data, the annual total number of newly identified HIV infections has been relatively stable since the late 1990s, and three studies report that the incidence of HIV has also been stable since the mid-1990s in populations for which time-trend data are available.[12] Our analysis assumed that there are about 1.75 million intravenous (IV) drug users; about one million live in areas where HIV prevalence among IV drug users is 20 percent; 600,000 live in areas where HIV prevalence is 10 percent; and the remaining 150,000 live in areas where HIV prevalence is 2 percent. There are about 1.7 million men who have sex with men in the United States, including 600,000 who live in major urban areas and who identify themselves as homosexual; we estimated HIV prevalence among this population to be about 0.2.[13]

Using CDC estimates, we assumed that 900,000 people are living with HIV: 700,000 people know that they have the infection, and two-thirds of these are receiving HIV treatment.[14] This leaves at least 200,000 people with HIV who do not know they are infected and 233,000 who know but are not receiving care.

Based on our personal communications with the CDC, we estimated that two million people are seen in U.S. clinics annually for the treatment of STDs. Another 2.3 million people are tested for HIV annually in voluntary counseling and testing sites (many of which are not in STD clinics); among these, 1.3 percent (29,900 people) test positive.[15] We estimated that each year about 20,000 people are newly identified as being HIV positive and could be referred to local health departments for partner notification. Previous studies suggest that newly identified people would each have an average of 2.7 sex or needle-sharing partners who might be located and counseled.[16] We also estimated that of the 281 million Americans, about 25 percent (70 million) might be reachable through a mass media campaign.

■ **Model validation.** To validate the model, we used it to estimate the number of new HIV infections that would occur annually without any interventions beyond those now in place. We used the population and HIV prevalence estimates for men who have sex with men, IV drug users who are not men who have sex with men (assuming that for those who do, sexual behavior is their primary route of infection), and high-risk heterosexuals. Our model predicted 38,136 newly infected cases, which is fairly close to CDC estimates of 40,000 new U.S. infections annually.

■ **Cost assumptions.** Intervention costs are highly dependent on the cost of living. In the base-case analysis, we assigned cost figures based on published studies.[17] For each intervention, we assume a fixed cost per unit of service in the range of population that could be reached. HIV treatment was estimated to cost about $20,000 per person per year, including the cost of three antiretroviral drugs, provider visits, laboratory tests to monitor progression, and hospitalizations.

■ **Effectiveness assumptions and resource allocation optimization.** The prevention benefit of the interventions directed at HIV-negative people was related to the estimated increase in condom use or to reductions in the number of sex partners, the frequency of sex, STD incidence or prevalence, or needle sharing. The prevention benefit of antiviral treatment of HIV-infected people was based on the theoretical potential of reduced transmission because of decreased viral load.[18] Our estimates of the potential benefits included reduction in the number of both primary and secondary infections (that is, the number of infections prevented among, respectively, people directly reached by the interventions and those who would otherwise be infected by the first group) but not tertiary infections or beyond.

We applied the population assumptions to the relevant interventions in "Maximizing the Benefit." We then ran the Solver program of Microsoft Excel, which is a general-purpose optimization modeling system that can be used to find the optimal set of input values that satisfy a set of simultaneous equations and constraints to maximize the objective function—in this case, the number of HIV infections prevented.[19] Three constraints were included. First, the budget was set at $400,000,000 to be spent directly on interventions (the remainder was set aside for indirect costs and infrastructure costs). Second, because HIV counseling and testing is a necessary service to link infected people to treatment and is now funded from prevention dollars, the model ensured that a minimum of one million people would be offered HIV counseling and testing even though its relative cost-effectiveness for prevention is lower than that of the other interventions. Third, we set a maximum limit for the number of people who could be reached based on the total population in each of the target groups in Exhibit 1.

After first allowing the model to choose among all interventions with these constraints, we then ran the model a second time using only the four strategies emphasized by the new CDC prevention initiative, with no constraints on the number of people provided with HIV counseling and testing. We also calculated the funds required to prevent 20,000 infections using only these four strategies.

To test the robustness of the optimal allocation of funds, we conducted a sensitivity analysis in which we reduced the effectiveness of the interventions by 50 percent and by 90 percent. Finally, because the cost of structural interventions (such as mass media, condom availability, and needle exchange) may vary considerably, we also ran the optimization model assuming that structural interventions might cost twice as much as our initial estimates.

## Study Results

The optimization led to an allocation of funds among interventions in descending order of cost-effectiveness (from most to least cost-effective). The one exception was HIV counseling and testing, which we required to serve at least one million people. In the first run of the model, which allowed all twenty-four HIV prevention interventions to compete, the optimization program selected nine interventions for funding. Allocating the funds optimally across these nine interventions resulted in 20,761 HIV infections prevented (Exhibit 2).

The intervention that could prevent the largest number of infections (nearly 9,000 per year) was community mobilization targeted at men who have sex with men.[20] Partner notification for HIV infection also had a potentially large benefit (2,230 infections prevented), but it was limited by the fact that only about 26,000 HIV infections are newly reported annually and many of these are anonymous or otherwise cannot be located.[21] Also potentially promising was screening for gonorrhea and chlamydial infection in HIV clinics, which prevents HIV infection by reducing the prevalence of these cofactors for transmission (1,606 infections prevented); however, these results assumed a level of prevalence of these infections that might not be seen in all localities.[22]

Needle exchange programs, which were cost-effective only where the HIV prevalence among IV drug users was 10 percent and above, could prevent 2,291 infections in high-prevalence and 388 infections in medium-prevalence cities.[23] Provision of risk-reduction videos in STD clinics was also relatively cost-effective (based in part on the low cost of implementation), but since only two million people could be reached in these clinics, this intervention could prevent only 580 in-

**EXHIBIT 2**
**Base-Case Optimal Allocation Of Resources For HIV Prevention**

| Intervention | People reached | Cost of intervention ($) | Infections prevented | Cost per infection prevented ($) |
|---|---|---|---|---|
| Videos in STD clinics, single session (O'Donnell et al. 1998) | 2,000,000 | 2,700,000 | 580 | 4,700 |
| Partner notification (Wykoff et al. 1991) | 54,000 | 13,500,000 | 2,230 | 6,100 |
| Community mobilization (Mpowerment) (Kegeles et al. 1996) | 600,000 | 109,096,000 | 8,921 | 12,000 |
| STD screening at HIV clinics (Farley et al. 2003) | 467,000 | 18,680,000 | 1,606 | 12,000 |
| Needle exchange—high-prevalence areas (Heimer et al. 1998) | 1,000,000 | 30,380,000 | 2,291 | 13,000 |
| Mass-media campaigns (Duboise-Arber et al. 1997) | 70,000,000 | 19,999,000 | 1,131 | 18,000 |
| Opinion leader programs (Kelly et al. 1992) | 600,000 | 22,851,000 | 994 | 23,000 |
| Needle exchange—medium-prevalence areas (Heimer et al. 1998; Kaplan 1995) | 600,000 | 18,228,000 | 388 | 47,000 |
| Condom availability/accessibility (Bedimo et al. 2002) | 24,905,725 | 90,566,000 | 1,920 | 47,000 |
| HIV counseling and testing—client-centered (Kamb et al. 1998) | 1,000,000 | 74,000,000 | 700 | 110,000 |
| Total [average] | >70,000,000 | 400,000,000 | 20,761 | [19,267] |

**SOURCES:** For a complete listing, see content.healthaffairs.org/cgi/content/full/24/5/915/DC1.
**NOTE:** STD is sexually transmitted disease.

fections.[24] Explicit mass media campaigns and condom availability programs, which were also cost-effective, could prevent 1,131 and 1,920 infections, respectively.[25] To achieve this effect, their reach would need to be broad, with mass media reaching at least seventy million and condom programs, twenty-five million.

Of the nine interventions selected by the model, counseling and testing was the least cost-effective at $110,000 per infection prevented, because of the relatively high cost per person reached ($74) and the relatively low HIV prevalence among those who seek testing. The optimized strategy included only the minimum number that we required to be served (one million). The interventions that were not funded are listed in Exhibit 3, along with the baseline cost to prevent one infection, all of which exceeded $110,000 per infection prevented.

When we limited the choice of interventions to the four interventions consistent with the new CDC HIV prevention initiative, only 7,315 infections were potentially prevented (Exhibit 4). To prevent 20,000 infections using only these four strategies, the federal HIV prevention budget would have to be increased from $400 million to $1.7 billion, the entire increase of which would be used for HIV counseling and testing, since the other strategies already reached the maximum number of people. Antiretroviral treatment of HIV-infected people was not selected as a prevention intervention to support because it costs $350,000 to prevent a single HIV infection through secondary prevention (more than the estimated lifetime cost of treatment of a newly infected person).[26]

**EXHIBIT 3**
**HIV Prevention Interventions That Were Not Chosen For Study**

| Intervention | Cost to prevent one infection ($) |
|---|---|
| Street outreach (Wendell et al. 2003) | 110,000 |
| Group counseling, multiple session (Shain et al. 1999) | 170,000 |
| STD screening and treatment in general population (Grosskurth et al. 1995; Farley et al. 2003) | 190,000 |
| Counseling and testing, standard model (Weinhardt et al. 1999) | 210,000 |
| Group counseling, multiple session (Kelly et al. 1994) | 320,000 |
| HIV antiviral treatment (Lepri et al. 2001) | 350,000 |
| Male circumcision (all males) (Weiss et al. 2000) | 340,000 |
| Counseling without testing, single session (Weinhardt et al. 1999) | 570,000 |
| Youth supervision programs (O'Donnell 1999) | 3,100,000 |
| Street outreach targeting women in low-income housing (Sikkema et al. 2000) | 3,400,000 |
| Drug treatment programs (Prendergast 2000) | 4,700,000 |
| Group counseling for youth, multiple session (St. Lawrence, 1995) | 15,000,000 |
| School-based education, multiple session (Coyle et al. 1999) | 21,000,000 |
| Community mobilization (Women and Infants Demonstration Project) (Lauby et al. 2000) | 41,400,000 |

**SOURCES:** For a complete listing, see content.healthaffairs.org/cgi/content/full/24/5/915/DC1.
**NOTE:** STD is sexually transmitted disease.

When we doubled the cost of the structural interventions (within a constant total budget of $400 million annually), the maximum number of people could still be reached for all except for condom distribution. This would reduce the number of people reached from twenty-two million to about three million, and the total number of HIV infections prevented, from 20,761 to 19,073.

## Discussion And Policy Implications

Although the assumptions and estimates used in our calculations are by no means precise, the results demonstrate the value of considering cost-effectiveness

**EXHIBIT 4**
**Optimal Allocation Of Resources Among Four HIV Prevention Interventions**

| Intervention | People reached | Cost of intervention ($) | Infections prevented | Cost per infection prevented ($) |
|---|---|---|---|---|
| HIV counseling and testing (client-centered) | 4,970,541 | 367,820,000 | 3,479 | 110,000 |
| HIV partner notification | 54,000 | 13,500,000 | 2,230 | 6,100 |
| STD screening in HIV clinics | 467,000 | 18,680,000 | 1,606 | 12,000 |
| HIV antiviral treatment | 0 | –[a] | –[a] | –[a] |
| Total [average] | 549,541 | 400,000,000 | 7,315 | [54,682] |

**SOURCES:** For a complete listing, see content.healthaffairs.org/cgi/content/full/24/5/915/DC1.
**NOTE:** STD is sexually transmitted disease.
[a] Intervention not chosen.

in strategic planning for prevention of HIV infection. In particular, the results highlight the importance of the HIV prevalence within specific populations and the cost of the intervention per person reached in determining the optimal use of limited resources for HIV prevention. Our model suggests that the optimal use of these resources would involve a combination of intensive individually focused interventions targeted at high-prevalence populations (men who have sex with men, IV drug users, and people known to be HIV-positive) and inexpensive large-scale interventions addressing lower-prevalence populations, and that the use of this combination of interventions could greatly increase the number of HIV infections prevented compared with the current U.S. strategy.

Mathematical models such as ours should be interpreted with caution. It is difficult to conclusively demonstrate that any intervention reduces HIV incidence in a population, and, even if effectiveness is assumed, the size of the prevention effect is often open to question. However, the relative cost-effectiveness of the different strategies is likely to be appropriate, even if the absolute estimates are not exact. An additional limitation of our optimization procedures is that they cannot determine whether some of the interventions (for example, community mobilization campaigns and opinion leader programs) can indeed be scaled up to reach the large number of people who could benefit from them. At the same time, many of the strategies are targeted at overlapping populations, so the number of prevented infections could be overstated. However, this limitation would be present to some degree in any strategic plan that employs multiple interventions, and it is not clear whether this would bias the results toward any particular type of intervention.

Taken together, the inherent limitations of our approach are such that the results should not be seen as a prescription for exactly how HIV prevention funds should optimally be spent, but rather as an indication of the types of interventions that should be emphasized to a greater or lesser degree.

Given that the majority of those infected in the U.S. HIV epidemic are still men who have sex with men or IV drug users, it should be no surprise that interventions targeting these groups (such as community mobilization and needle exchange) tend to be the most cost-effective and are high priority for funding in an optimized allocation of resources. HIV partner notification, which targets HIV-positive people and their partners, also yields large benefits per dollar spent and thus is also of high priority under an optimized scheme. The model did not fully evaluate the potential benefit of repeated or continued efforts to work with HIV-positive people to maintain their safer-sex behavior or to counsel their sex partners, but, if effective, such interventions could also prove to be cost-effective because of the high probability of transmission in these partnerships.

Interventions that address low-prevalence populations are relatively cost-effective only if they cost little per person reached. Among those interventions directed at low-prevalence populations, the optimization procedure allocated funds to increases in condom availability programs and mass-media campaigns, which meet this criterion of low cost per person reached (as opposed to interventions dependent on face-to-face interactions, which are costly). Together, these two interventions were estimated to prevent more than 3,210 infections annually.

We did not include two interventions that would likely prevent HIV transmission—needle deregulation and alcohol taxes—because their cost cannot be measured in units of service; rather, they are implemented through legislation. However, if administration costs were about $100,000 per state, we estimated that they might respectively prevent 6,166 and 1,067 HIV infections.

Our calculations suggest that the emphasis of the new CDC HIV prevention strategy could prevent considerably fewer HIV infections than an optimal allocation of resources because of its heavy emphasis on counseling and testing, which has a low relative cost-effectiveness because few people who receive a voluntary HIV test are HIV-positive. In fact, our calculations may be optimistic about the yield of HIV testing, as the prevalence and incidence of HIV in the most highly affected population group is found in STD clinics, and even in that setting only 3 percent are HIV-infected.[27] HIV prevalence in U.S. populations outside of STD clinics is lower, which makes counseling and testing decreasingly cost-effective if it were expanded to other settings. Furthermore, our calculations of the effectiveness of HIV counseling and testing are based on the client-centered counseling method, which is much more cost-effective than the standard counseling that is taking place in most U.S. sites. The cost-effectiveness of the rapid testing method for HIV prevention is unknown but is not likely to be more effective in promoting behavior change than standard testing, which is estimated to cost $210,000 per case prevented. It is unlikely that this higher cost would be offset by the increase in the number of people learning their HIV status. Furthermore, early reports on the ability to find high-prevalence populations in clinical and nonclinical settings are disappointing. Selected emergency departments have found HIV prevalences that vary from 1 to 5 percent, but in nonclinic settings the prevalence has been less than 1 percent, which suggests that taking rapid tests to nonclinical settings would not be an efficient use of resources in local communities.[27]

The new CDC strategy calls for increasing the percentage of people who know they are infected from 75 percent to 95 percent. Achieving this goal would require that an additional 160,000 HIV-positive people learn of their status. If the prevalence in the tested population were 1–3 percent, then 5.3–16 million people would need to be screened—more than could be screened by shifting the entire CDC HIV prevention budget to the four new prevention strategies.

It is impossible to know exactly how many infections are being prevented by the interventions already in place. Localities report on their spending by the number and characteristics of people reached, not by content. Voluntary counseling and testing is the exception, because well-defined protocols exist. However, the fact that the estimates and reports of new infections have not greatly declined in more than five years suggests that the impact of HIV prevention efforts has reached a plateau. This implies that greater emphasis should be given to selecting cost-effective strategies instead of expanding the use of strategies that are inherently limited or costly.

Our results indicate that some relatively inexpensive, broad-based prevention interventions, which reach large segments of the population, continue to have value. It is likely that many new HIV infections arise from people who do not know or do not wish to know whether they are HIV-positive. Although our model is designed to consider the nation as a whole, localities could use resource allocation models similar to that used here to customize a portfolio of strategies to optimize their efforts.

Political considerations are involved whenever HIV prevention strategies are planned. There is clear opposition to some of the structural interventions supported by this optimization process, such as efforts to raise alcohol taxes, conduct mass-media campaigns, expand needle-exchange programs, and deregulate the purchase of needles and syringes. At the other end of the spectrum, attempts to reduce funding for intensive interventions targeted at relatively low-risk people, such as youth and women, would likely also meet with opposition. In addressing this political opposition, public health officials would benefit from a rational allocation scheme, such as that used here, which maximizes the number of infections prevented.

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## NOTES

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